QUANTUM TECHNOLOGIES IN SPACE

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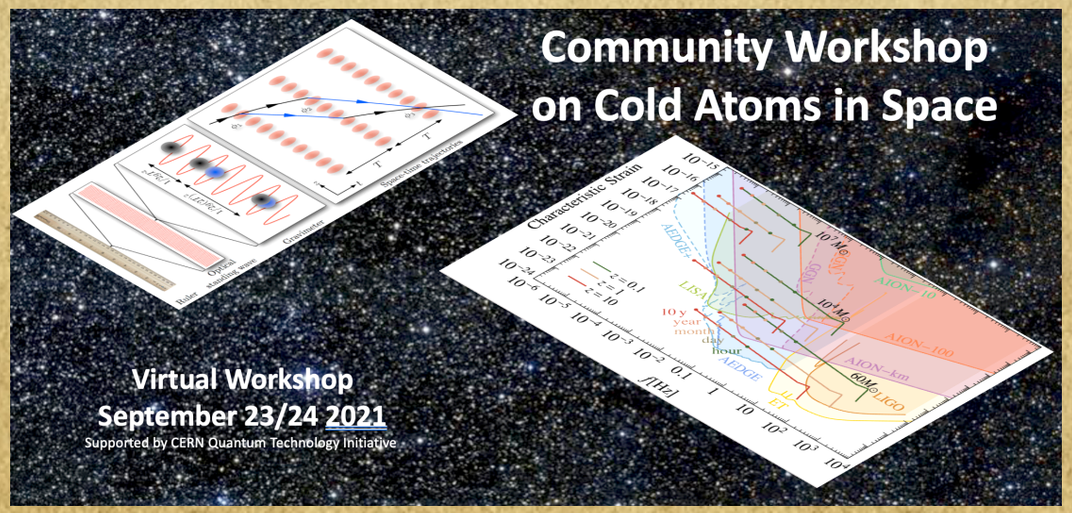


23 September 2021

QTEQ QUANTUM TECHNOLOGY at QUEEN'S

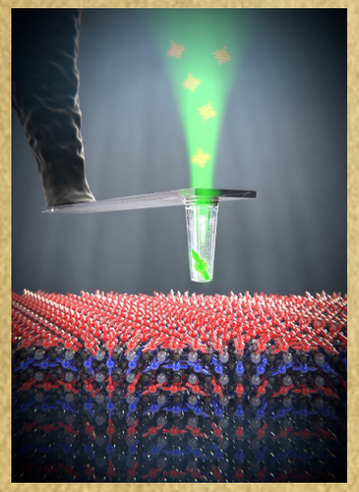
Quantum technology

Quantum Computing

Energy saving: Quantum computers can consume much less energy than classical ones

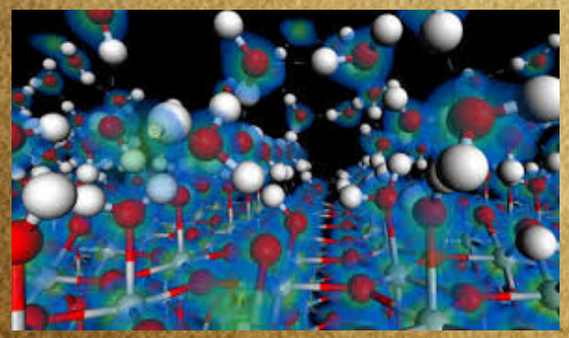
Computational advantages: Quantum computers can solve problems much faster than classical ones

Quantum Sensing



Enhanced sensitivity: Quantum laws allow to reveal ultra-weak signals or measure tiny masses

Unrivalled precision: Quantum laws allow for sensing with precisions better than any classical sensor

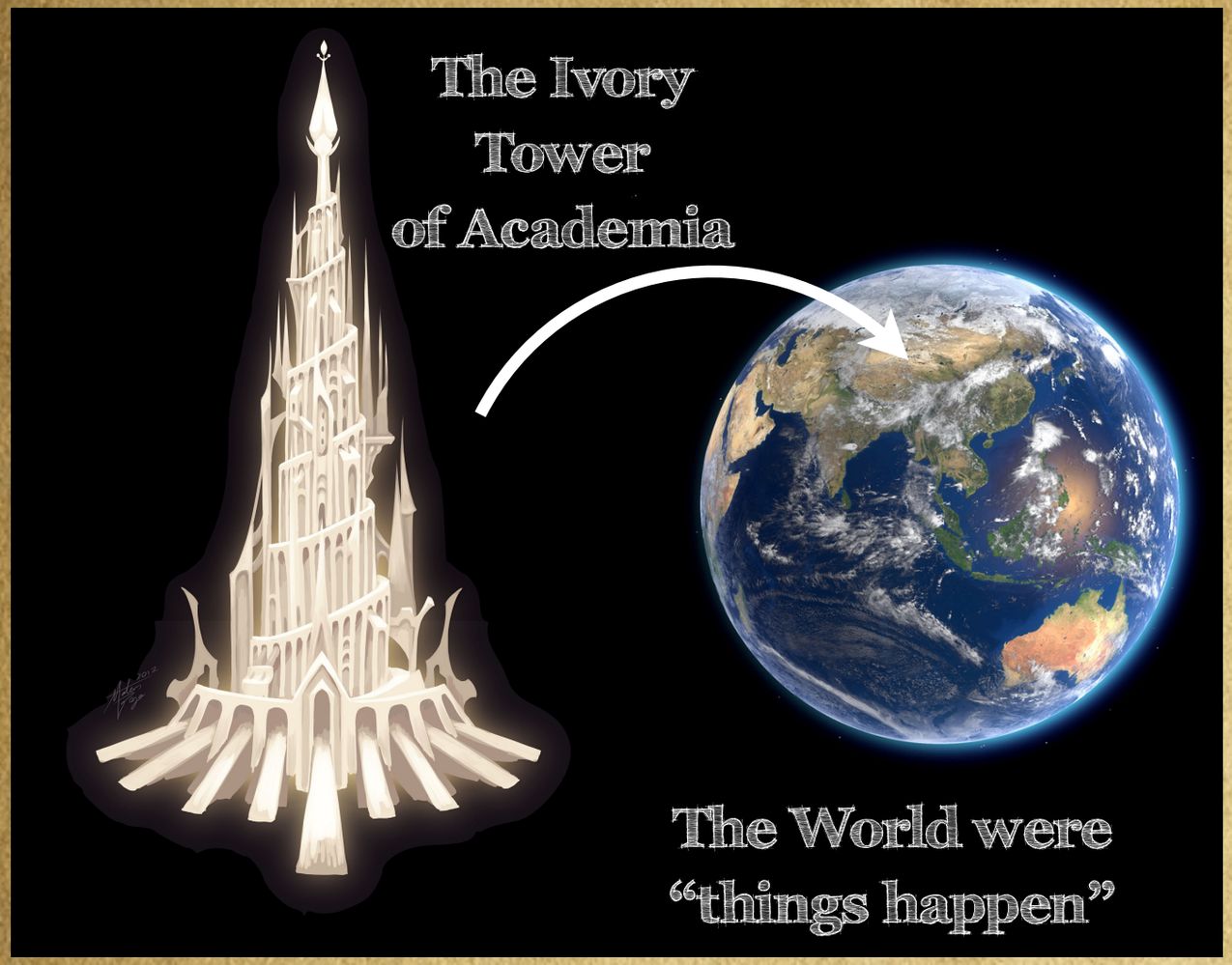


Quantum Simulation

Taming complexity: Quantum simulators will allow to reproduce the features of complex processes

Unrivalled predictions: Quantum simulators will allow to design materials and drugs that DO NOT yet exist

Initiatives worldwide



UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME

2014—2024: £ 214M capital investment

QUANTUM FLAGSHIP

EU-funded: € 10B over 10 years

Centre for Quantum Technologies

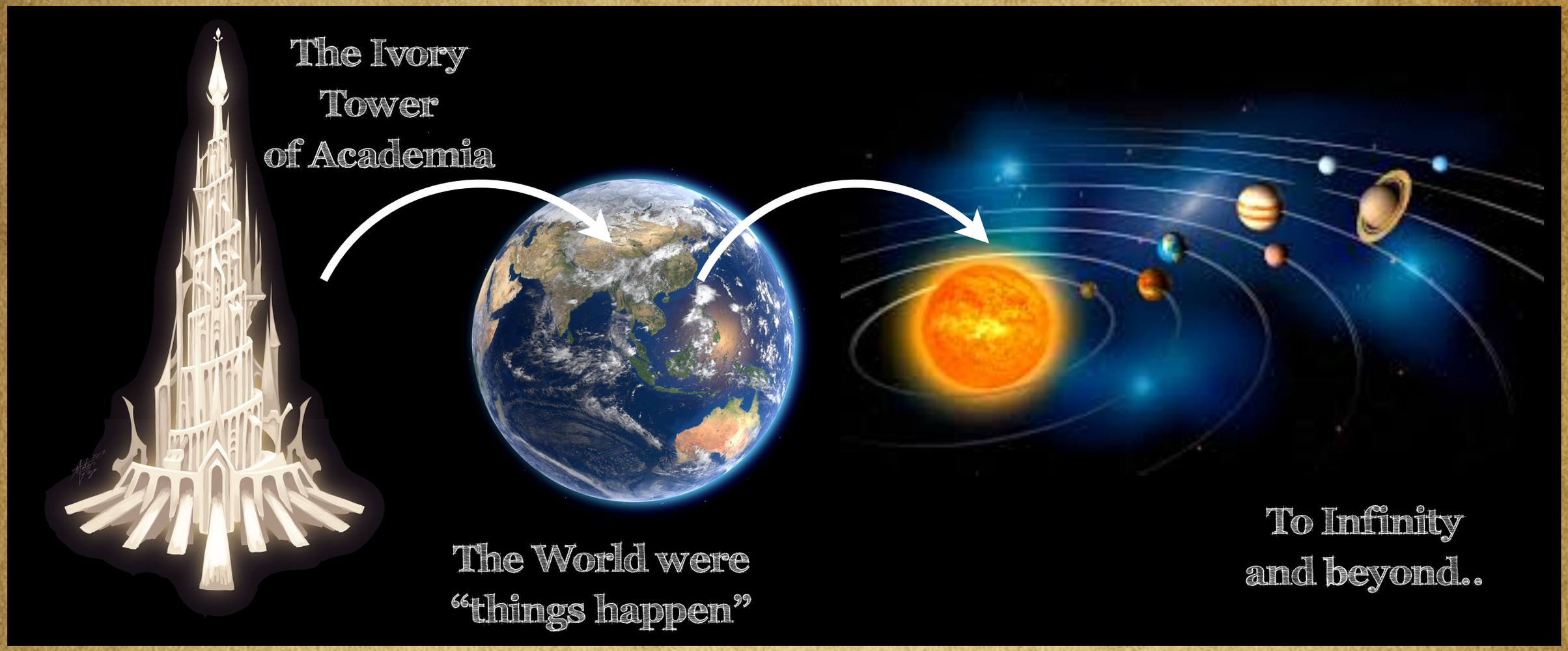
DEFENCE INDUSTRY & INNOVATION
NEXT GENERATION TECHNOLOGIES FUND

US National Quantum Initiative Act
$ 1.2B from 2019

China: 517 quantum tech patents only in 2018

QTEQ QUANTUM TECHNOLOGY at QUEEN'S

Initiatives worldwide



QTSPACE QUANTUM TECHNOLOGIES IN SPACE

esa

QUANTUM FLAGSHIP

COST Action "Quantum Technologies in Space": € 0.5M to develop a QTSpace community

European Commission

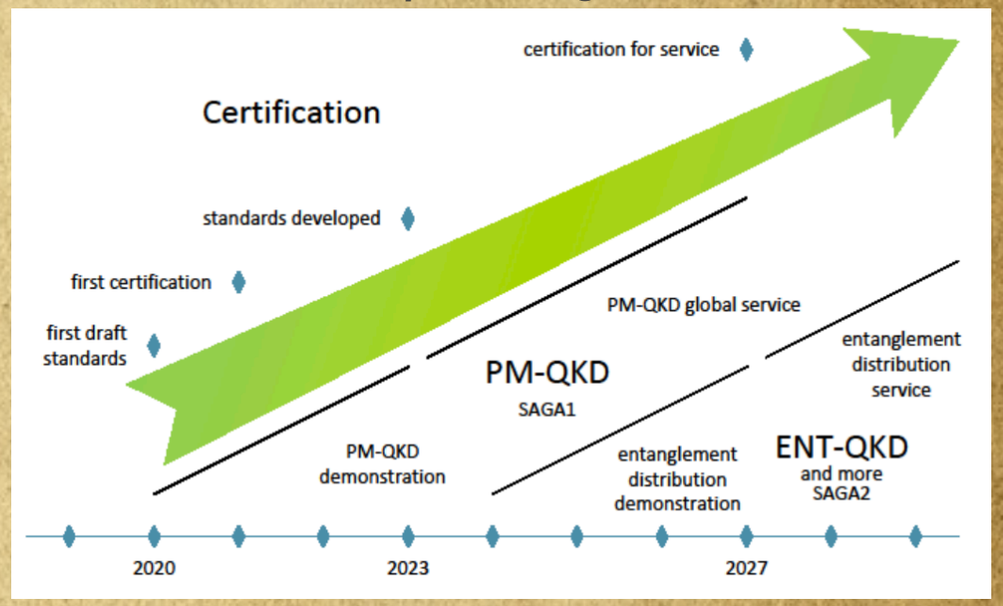
The four pillars of the White Paper

Secure Quantum Communication – QC

A roadmap for space-based secure quantum communication

Operational systems. *SAGA (Security And cryptoGrAphic mission) was originally an ESA internal study for ENT-QKD. In this context, we use SAGA as reference to the space segment of the future QCI, comprising different types of implementation*

Standards/certification development



R&D on security, quantum concepts, system concepts

A vision for financial support

QTEQ QUANTUM TECHNOLOGY at QUEEN'S

The four pillars of the White Paper

Time and Frequency Transfer – TFT

Time standards and frequency transfer-based applications

Precision time standards are at the root of modern day metrology. They are an enabling factor in a trade-based economy. In radio astronomy recently real time imaging of a black hole has been demonstrated using synthetic aperture imaging for radio frequency signals. This was enabled by TFT technologies.

Quantum enhanced performance, quantum enabled applications

High precision clocks in space will provide a secure (i.e. hard to jam) and independent time base for global time keeping. Combined with space-space and space-ground optical links they will allow global TFT.

Roadmap for QT enhanced TFT

Short-term goals (5 years)

Medium-term goals (10 years)

An in-orbit technology demonstration of the selected optical clock concept with a goal accuracy of 10^{-18} shall be realized.

Long-term goals (> 10 years)

- Universal time dissemination
- Geodesy service
- New GNSS architectures
- Gravitational wave detection at low frequency
- Fundamental physics experiments
- Optical synthetic aperture telescopes

The four pillars of the White Paper

Earth Sensing and Observation – EO

The need for Space-Based Quantum Sensing

In light of climate changing, earth observation is maybe the most important scientific endeavour of our times. The study of global mass transport phenomena via satellite gravimetry provides important insights for the evolution of our planet and climate change, by improving our understanding of the distribution of water and its changes.

Quantum mapping of the Earth' mass dynamics

Atom-interferometric quantum sensors offer long-term stability and high sensitivity. Quantum sensors are already officially considered by ESA as a potential instrument, or a demonstrator. ESA future geodesy mission classified as Mission of Opportunity, Next Generation Gravity Mission, will include laser ranging but consider quantum sensors as a candidate for the following mission if the technology is ready at that time.

A roadmap for quantum sensors for Earth sensing and observation

The final goal is to perform a geodesy mission using one or multiple space- borne quantum sensors; exploit quantum sensors for applications such as navigation, exploration and planetology (moon, mars) (> 10 years).

The four pillars of the White Paper

Fundamental Physics – FP

QT developments - three platforms: photons, atoms, optomechanics

Available QTs for a fully fletched FP mission include: classical and non- classical optical interferometry, the generation of non-local superpositions and entangled states, and the demonstration of robust in the field quantum information protocols with photons.

Atomic clocks and interferometers resembling the most precise meters and clock around building on quantum superposition states are getting ever more robust and compact.

Optomechanical systems and matter-wave interferometers are pushing the boundaries of macroscopic quantum states in laboratory environments.

Drawing a roadmap for FP with QT in space

In the medium term (5-10 years), the FP community needs support to develop demonstrators for tests in microgravity environment and has to define pathfinders for validation of QT in orbit

The long-term goal (> 10 years) is to exploit QT for the scientific objective to test quantum mechanical states in an ESA mission with/without worldwide partners.

The future is quantum!

THANK YOU

http://www.qtspace.eu/?q=whitepaper